Sexual presence and intentional dynamics: deviant and non-deviant sexual self-regulation from the first person stance

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ABSTRACT

Child molesters (n=13) and sexually non-deviant subjects (n=29) were immersed with virtual characters depicting relevant sexual features while their sexual arousal and gaze behaviour were assessed to characterize their sexual preferences and intentional dynamics. Sexual arousal was measured using circumferential penile plethysmography (PPG). Gaze behaviour dynamics was derived from average gaze radial angular deviation (GRAD) and GRAD coefficient of variation (GRADCV). Results show distinct sexual arousal profiles according to sexual preferences and point towards the existence of specific gaze behaviour dynamics guided by sexual intentions. Theoretical interpretations are based on the ecological psychology of J.J. Gibson and the integrated theory of sexual offending (Ward, 2009; Ward & Beech, 2006). Theoretical underpinnings coming from these approaches are advocated as being especially well suited to explain how virtual reality can help probing into child molesters' phenomenology as lived from the first-person stance.

1. INTRODUCTION

Deviant sexual interest represents one of the strongest determining factors in recidivism among sexual offenders in general and among child molesters in particular (Hanson & Bussière, 1998; Hanson & Morton-Bourgon, 2005). There is increasing recognition, however, that the other factors generally taken into account, i.e., emotional regulation problems, cognitive distortions and social difficulties, are intimately linked to deviant sexual preferences and act synergistically to make way for committing the deviant act (Hanson & Harris, 2000; Proulx, Perreault & Ouimet, 1999; Ward & Beech, 2006). According to the "integrated theory of sexual offending" (ITSO) proposed by Ward and Beech (2006), etiological sources are to be primarily found either in neuropsychological predispositions acquired by in the course of ontogenesis or else in the phylogeny of hominids under the impact of selective pressures acting directly or indirectly on sexual behaviour (Fisher & Thomson, 2007; Joyal, Black & Dassylva, 2007; Lalumière & Quinsey, 1999; McKibbin, Shackelford, Goetz, & Starratt, 2008; Quinsey & Lalumière, 1995; Redouté et al., 2000; Stoléru et al., 1999; Stone , 2007). In this matter, when child molesters are presented with visual sexual stimuli depicting children, their deviant sexual arousal seems to be associated to hypoarousal of temporal structures of the brain involved in the inhibition of sexual arousal and/or to activation of the orbitofrontal area (Joyal et al., 2007; Moulier & Stoléru, 2007). Quinsey and Lalumière (1995) hypothesize that paedophiles' body shape detectors/appreciators are failing to function normally, which would account for arousal to prepubescent sexual characteristics in paedophilic individuals. Providing support to the hypothesis on perceptual and cognitive deficits in paedophiles and child molesters are results showing that offenders present a higher prevalence of attention deficit hyperactivity disorder (Kafka & Hennen, 2002), a slower general processing speed (Suchy, Whittaker, Strassberg & Eastvold, 2009a), problematic visual-spatial memory (Cantor et al.,

2004) and difficulties in recognizing facial affect (Suchy, Whittaker, Strassberg & Eastvold, 2009b). These neuropsychological impairments could originate from neurodevelopmental perturbations, as exemplified by structural anomalies found in the frontal lobes and amygdala of these individuals (Schiffer et al., 2007; Schiltz et al., 2007).

Distal neurobiological predispositions subsequently require proximal causes, i.e. a given environmental setting as well as a specific social role to occupy in this context – an ecological niche (Ward & Beech, 2006) – in order for actual symptoms to be generated. It would be from the dynamics of the relationships forming between these distal and proximal factors that the observable symptoms, particularly deviant sexual arousal, would then emerge through self-regulated processes. Self-regulation of offending is fundamentally based on a combination of internal and external processes which drive a person to manifest goal-oriented behaviours (Ward & Beech, 2006; Ward & Hudson, 1998). This behavioural regulation process, which is conducted over time and different contexts, takes effect through the modulation of attention and perceptual-motor processes (Baumeister & Heatherton, 1996; Karoly, 1993; Ward & Hudson, 1998). When applied to sexual offenders, this concept provides an explanation for the dynamic variations in intentionality, which in turn reflect the existing hierarchical relations between sexual motivation, inhibiting processes, deviant sexual arousal and the sexual aggression itself.

2. ITSO AND ECOLOGICAL PSYCHOLOGY

The Gibsonian ecological conception of optics gives an explanation of how the visual world is grasped from the first-person stance, i.e. as embodied and embedded in an actual context. When used to understand child molesters' phenomenology, ecological psychology might serve as theoretical tools to more fully grasp deviant sexuality as actually lived in specific contexts by these individuals. Ecological psychology can indeed help in building bridges between ITSO's factors, namely biological, neuropsychological and ecological factors. Ecological psychology is well suited to explore and shed light on the role of the interlocking neuropsychological functions put forward in ITSO, especially perception and action selection and control. As a psychological theory of perception, ecological psychology might give ITSO a rationale to contextualize self-regulation of offending. Moreover, Gibsonian psychology is a natural when it comes to give virtual reality a detailed reading of the perceptual-motor processes engaged in immersive experiences (Carr and England, 1995).

2.1. Perceptual Invariance Extraction: Getting Visual Information to Guide Sexual Behaviour

According to the Gibsonian approach, perception exists to allow adapted motor activity and, reciprocally, motor activity is there for perception to occur in a flexible dynamic manner to fit in biological functions, including sexual activity. In order to actualize this agent-environment regulation process, perceptual-motor dynamics must supply stable and reliable reference points about what the environment affords at the behavioural level. This mutuality of action and perception, which is fundamental in ecological psychology, makes the living organism an active agent within its environment (Chemero, 2009; Gibson, 1979; Renaud, Chartier, & Albert, 2009; Renaud, Singer, & Proulx, 2001; Schöner, Dijkstra, & Jeka, 1998; Schöner & Kelso, 1988; Turvey & Shaw, 1999; Varela et al., 1991; Warren, 2006).

In order to extract this guiding invariant information from the environment the visual system must consider both the position of the objects and the motion of the observer, which are found simultaneously in the optic flow (Gibson, 1950; Kim & Turvey, 1999; Warren, 1995, 2004). Optic flow can be defined as the active first-person experience of the changing ambient optic array. The ecological explanation of perceptual invariance extraction is in fact based on the active using of the optic flow. Perceptual invariance extraction comes from effective covariances between information from the optic flow field and actions oriented toward a goal (Lee, 1980; Renaud et al., 2009; Renaud, Goyette et al. 2010; Warren, 2006). For instance, the self-regulation of sexual offense requires the extraction and organization of critical perceptual information from the immediate surrounding (victims, location, resources, potential threats) in order to be efficiently carried out.

2.2. Self-Regulated Intentional Dynamics

To the biomechanical and environmental constraints we must add intentional constraints that map out the agent's actions according to his punctual behavioural objectives. Intentional constraints produce their own dynamical effects by causing a pattern of perceptual-motor coordination to persist in time and in different environments (Renaud et al., 2009, Renaud, Goyette et al., 2010; Richardson, Marsh, Isenhower, Goodman & Schmidt, 2007; Shaw, 2001; Shaw & Kinsella-Shaw, 1988; Tschacher & Haken, 2007; Van Orden & Holden, 2002; Van Orden, Holden, et al., 2003; Van Orden, Moreno, et al., 2003). In a visual search task, for instance, intentional constraints will serve to limit the search space to better circumscribe the location of information that is immediately relevant to the established behavioural objectives (Renaud et al., 2009). In a

similar fashion, distinct behavioural coordination patterns may be detected as signatures or markers of intentions springing from neuropathological or psychopathological conditions or predispositions (Reidborg & Redington, 1995; Renaud, Bouchard & Proulx, 2002; Renaud, Goyette et al., 2010; Thelen & Smith, 1994; Tschacher & Junghan, 2009). Deviant sexual preferences and intentions could well be expressed through that kind of behavioural coordination patterns (Renaud, Goyette et al., 2010). For example, a child molester entertaining intentions to sexually abuse a child would self-regulate his or her action through perceptual-motor and psychophysiological patterns of preparation. These coordinated patterns would express the active picking-up of critical visual information on which is based the recognition of prepubescent features as well as the associated sexual arousal. In this sense, any environments, real or virtual, actual or fantasized, can induce sexual presence as long as they afford the agent opportunities to enact his or her sexual intentions (Lepecq, Bringoux, et al., 2009; Renaud, Goyette et al., 2010; Riva, 2009).

2.3. Sexual affordances: critical information for self-regulation of sexual behaviour

Still according to ecological psychology, the affordances of an object, event, or environment are the opportunities for action that the object, event or environment offers the active agent (Gibson, 1979). These affordances are directed simultaneously toward both the agent and the environment as they instantiate at the perception-action level the instantaneous coupling between both entities. They are specified in the ambient optic array and are as such part of an extended information bearing structure that narrows the agent-environment gap (Chemero & Heyser, 2009; Rowlands, 2010). Affordances are enacted or caused to emerge in the optic flow by the active agent to guide him in return in his actualizing of intentions (Shaw, 2001; Varela et al., 1991).

With respect to sexuality, sexual affordances can be perceived as referring to the objects, events and environments in resonance with sexual behaviours, including seduction and approach behaviours as well as sexual arousal itself (Renaud, Goyette et al., 2010). Human sexual affordances seem very diversified, even though most of them are likely the product of prototypical forms linked to the reproductive act between male and female congeners. There exist many forms of sexual affordances resonating with the different sensory modalities. At the visual level, for instance, we know that human beings are generally attracted to specific waist-to-hip ratios, as well as body symmetry and other visible signs of health and fertility (Miller, 2000; Singh, 1993, 1994, 1995; Sugiyama, 2005). Sexual affordance constitutes a particular instance of social affordance in which social coordination has a crucial biological meaning pertaining to reproduction (Marsh, Richardson & Baron, 2006; Miller, 2007; Renaud, Goyette et al., 2010; Richardson et al., 2007; Withagen & Chemero, 2009).

On a perceptual-motor level, sexual affordances should correspond to the invariances whose perceptual extraction will generally guide the sexual response. The orientation and approach motor behaviours that prepare for the sexual act, i.e. genital arousal accompanied by behaviour directed towards physical contact, would be associated to such sexual affordances. Lykins, Meana and Kambe (2006) as well as Rupp and Wallen (2007) for instance found distinct eye movements in normal subjects viewing pictures of sexual content, whereas subjects were visually scanning stimuli for sexually significant information accordingly to their sexual interests, gender and hormonal disposition. In that sense, the ocular dynamic could possibly be modulated by the level of sexual explicitness contained in the stimuli (e.g. the presence or absence of nudity or sexual activity): subjects tend to show a higher number of fixations and to spend more time on the whole body rather than the head when watching stimuli depicting erotic activities while the opposite tends to occur for non-eroctic stimuli (Lykins et al., 2006; Lykins, Meana & Strauss, 2008). Furthermore, men tend to express an initial fixation on the chest and waist, and then on the rest of the body during the presentation of photographs altered by computer depicting nude women (Dixson, Grimshaw, Linklater & Dixson, 2011), showing that the temporal scan path dynamic could also be modulated in the same way. Finally, Renaud and colleagues found distinct motor and oculomotor patterns linked to deviant and non-deviant sexual interests in subjects virtually immersed with sexual stimuli (Renaud et al., 2007; Renaud, Goyette et al., 2010; Renaud, Rouleau, Granger, Barsetti, & Bouchard, 2002).

3. AIMS AND HYPOTHESES

This study aims to compare the respective sexual arousal responses and the perceptual-motor patterns of child molesters and sexually non-deviant subjects. These responses are measured while the subjects are exposed to synthetic sexual stimuli in virtual immersion. As a first hypothesis, we expect sexual arousal response profiles to be different for child molesters and controls according to their preferred sexual stimuli. As a second hypothesis, perceptual-motor patterns are expected to vary across groups in accordance with the geometry and sexual significance of the stimuli to which subjects are exposed.

4. EXPERIMENTAL METHOD

4.1. Participants

Thirteen male child molesters were recruited to compose the clinical group. Twelve of them had been formally recognized as being guilty of sexual aggression against children and one admitting to have pedophiliac interests and using juvenile pornography. The child molesters group included one homosexual participant the remaining members of this group were heterosexuals. Four of them reported a sexual preference for children while the others had sexual interests for children and adults. These participants came from the Royal Ottawa Forensic Program, the Centre de psychiatrie légale de Montréal (CPLM) and the Centre d'Étude et de Recherche de l'Université de Montréal, where they were living in community and involved in treatment or pre-sentence assessment. Four participants of the child molesters group were under anti-androgenic medication and nine were taking antidepressants or mood stabilisers. Most of them were in group treatment addressing their sexual problematic.

Twenty-nine (29) non-deviant male subjects were recruited from newspaper ads to compose the control group. These participants did not have a criminal record and asserted that they did not have sexual interests toward children. The ND group consisted of five homosexuals, one bisexual and twenty-three heterosexuals.

Mean age of the child molesters group was 42 years (SD 10.8) while ND group was 41.9 years (SD 10.4). Subjects of both groups were matched according to their education level and socioeconomic status. Participants were met at the Laboratoire de cyberpsychologie (Université du Québec en Outaouais and Institut Philippe-Pinel de Montréal).

4.2. Procedure

Once at the laboratory, subjects were briefed about the study and signed a consent form in which it was clearly stated that their results would not be used in any correctional or legal process and would remain strictly confidential. It was also made clear to the subjects that they could withdraw from the study at any time. Ethic committees from UQO, Institut Philippe-Pinel de Montréal and the Royal Ottawa Hospital approved the research protocol.

The subjects were briefed and given a five-minute period of habituation with the experimental setting. They were then asked simply to pay attention to the 3D animations in which they were about to be immersed for five 90-second periods (60 seconds with the virtual character and the last 30 seconds without). Virtual characters were presented in an empty room in the following randomly chosen order: Female adult, Female child, Male child, Male adult, and Neutral. There were five separate animations (one per category) and participants were presented once with each. Erectile response had to return to the baseline between stimulus presentations. After the experiment, the subject was debriefed and given a $50 remuneration. The entire procedure lasted on average one hour and 30 minutes, including reception, screening questionnaires and debriefing.

4.3. Materials and Measurements

4.3.1. Sexual Stimuli and Virtual Reality Simulators

Virtual characters were used as sexual stimuli (see figure 1). They were designed, developed and validated to simulate Caucasian mesomorphic body types according to Tanner's developmental criteria to fit targeted age categories: Adults between 22 and 25 year old and Children between 10 and 13 year old (Renaud, Rouleau et al., 2010; Tanner, 1973). A sexually Neutral character without textures was also used as a measure of control. These characters were animated to simulate a neutral emotional attitude, i.e., an idle position with subtle body movements (head movements, blinking, slight rotations of the torso). These animations were developed using a infrared motion tracking system and the movements of actors wearing data suits. Subjects were immersed with life size versions of these characters which were all positioned at the same distance and at the same level from the subject. Adult and Neutral stimuli subtended 44 degrees of vision angle while Child stimuli subtended 27.5 degrees.

A CAVE-type immersive system and a head mounted display were used to present the sexual stimuli (see figure 2; Cruz-Neira, Sandin, DeFanti, Kenyon & Hart, 1992; Renaud et al., 2009). Head position and orientation coordinates were provided by a motion tracker system. Subjects were put in virtual immersion while their erectile and oculomotor responses were recorded simultaneously.

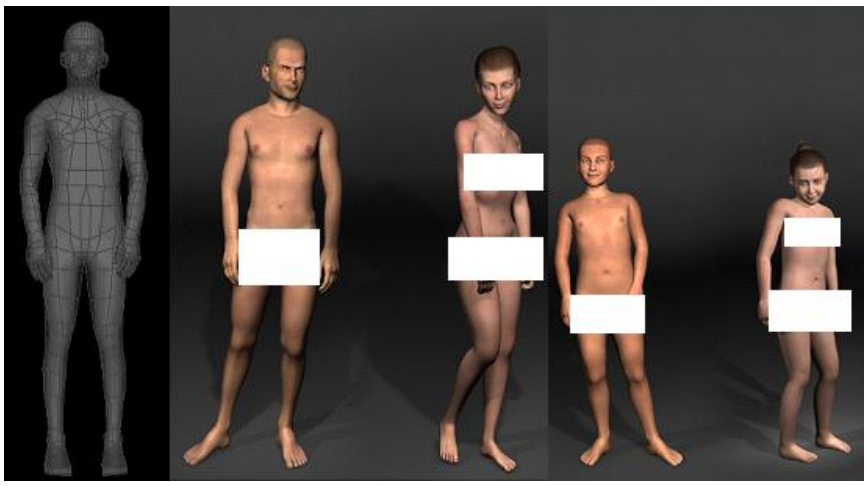

Figure 1.Virtual characters used as sexual stimuli: left to right, Neutral, Male adult, Female adult, Male child and Female child.

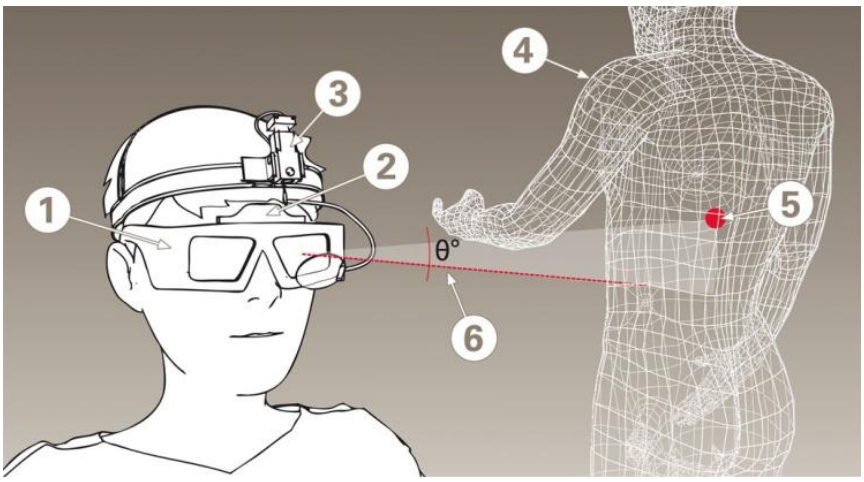

Figure 2.Gaze behaviour recording in virtual immersion: 1) active Nuvision 60GX stereoscopic glasses 2) IS-900 motion tracker from InterSense 3) oculomotor tracking system (ASL model H6) 4) virtual character in wired frame 5) a virtual measurement point (VMP) 6) a gaze radial angular deviation (GRAD) from the VMP.

4.3.2. Penile Plethysmography

Penile plethysmography (PPG) measures variations of blood volume in the penis and is used particularly to assess sexual arousal (Freund, 1965; Laws & Marshall, 2003). Circumferential PPG requires the wearing of a thin mercury-in-rubber strain gauge around the shaft of the penis. This gauge is a small rubber tube filled with mercury forming a ring. During an erectile response, the gauge stretches and changes in the mercury column produces variations in electric conductibility which is expressed in voltage gradient.

The erectile response value obtained in each test corresponds to the difference between the highest value recorded during the test and the lowest preceding value measured from the start of the same test. In order to reduce inter-individual variability inherent to erectile responses, raw scores were transformed into ipsative scores, i.e., into the computation of z-scores made across the five categories of virtual characters, for each individual participant (Blanchard, Klassen, Dickey, Kuban & Blak, 2001, Blanchard et al., 2006). Ipsative scores describe a person's performance in comparison to himself by making all individual scores sum to a constant. A drawback to ipsative scores is that any relation to the absolute value of the targeted attribute is lost. When it comes to assessing individual sexual preferences this drawback can become an asset. These intra-individual z-scores were used as dependent variable in the statistical analyses.

4.3.3. Gaze measurement technique

Our method performs gaze analysis by way of virtual measurement points (VMPs) placed over virtual objects (see figure 2; these VMPs were not visible to the subjects in virtual reality immersion). The gaze radial angular deviation (GRAD) from VMPs is obtained by combining the six degrees of freedom (DOF) resulting from head movements and the two DOF (x and y coordinates) resulting from eye movements tracked from an eye-tracking system (Duchowski et al., 2002; Renaud, 2006; Renaud et al., 2009). While variations in the six

DOF developed by head movements define momentary changes in the global scene experienced in immersion, the two DOF generated by the eye-tracking device allow line-of-sight computation relative to VMPs. GRAD measurement gives a continuous taking-into-account of gaze probing in a three-dimensional space relative to the positions of objects arranged therein. The closer this measure approaches zero, the closer the gaze dwells in the immediate vicinity of the selected VMP. For the present study, VMPs were edited on the genitalia of each character. Data were sampled at 60 Hz. The resulting GRAD time series for each subject in each condition contained 3,600 data points from which analyses were performed (see Figure 3 for examples).

In addition to the average GRAD, GRAD velocity (GRADV) and GRAD coefficient of variation (GRADCV) were computed for each individual GRAD time series. GRADV was obtained from the absolute value of the signal's first derivative. GRADCV, a measure of dispersion of the visual behaviour around VMPs, was computed from the ratio between standard deviation and mean value of the signal (SD/M). The coefficient of variation is used as a normalized index of dispersion or variability of motor behaviour (Hausdorff, 2005; Sosnoff & Voudrie, 2009). For instance, some neuropathologies, and aging in general, are characterized by more variability and lower control over motor behaviour, i.e. by motor dynamics with higher values of coefficient of variation.

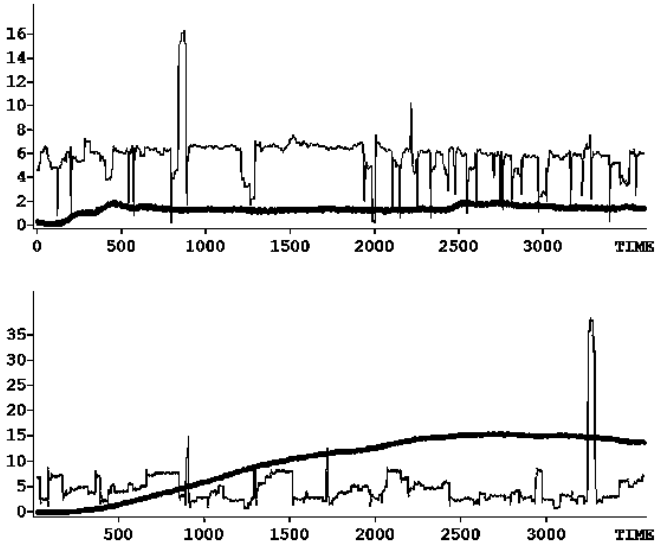

Figure 3. GRAD (in thin lines; deg) and PPG (in bold lines; mm) for a typical sexually non-deviant subject (upper panel) and a typical child molester (lower panel), with the female child stimulus.

5. DATA ANALYSIS

5.1. Data pre-processing

GRAD data time series were first filtered to remove any measurement disruptions caused by signal losses. Three outliers had to be removed from the analysis, their Mahanalobis distance was too high on the GRAD variable (Cousineau & Chartier, 2010). The same had to be done with seven other subjects because of major measure artefacts, four because of GRAD data acquisition and three because of PPG's.

5.2. Statistical analysis

Four repeated measures ANOVAs with Groups (Non-deviants vs. child molesters) and Stimuli (Neutral, Adults, Child) were performed on the dependent measures, PPG, GRAD, GRADV and then GRADCV (also called mixed, within-between subjects design, split-plot or randomized blocks factorial). Univariate tests and pairwise comparisons were used to compare Groups and Stimuli. An alpha level of 0.05 was used for all statistical tests.

6. RESULTS

Using Wilks's Lambda criterion, a first repeated measures ANOVA gives a significant Groups by Stimuli interaction effect on PPG (Λ=0.787; $F(2,37)=5.006$; $p < .05$). Univariate tests further show significant group differences on Adult ($F(1,38)=1.562$; $p < .05$) and Child stimuli ($F(1,38)=2.621$; $p < .01$), but not on the

Neutral stimulus (F(1,38)=0.572 ; p =N.S.); child molesters present a sexual arousal profile with significantly more pronounced erectile responses when facing Child stimuli, the opposite being true for sexually non-deviant participants with Adult stimuli (see figure 4).

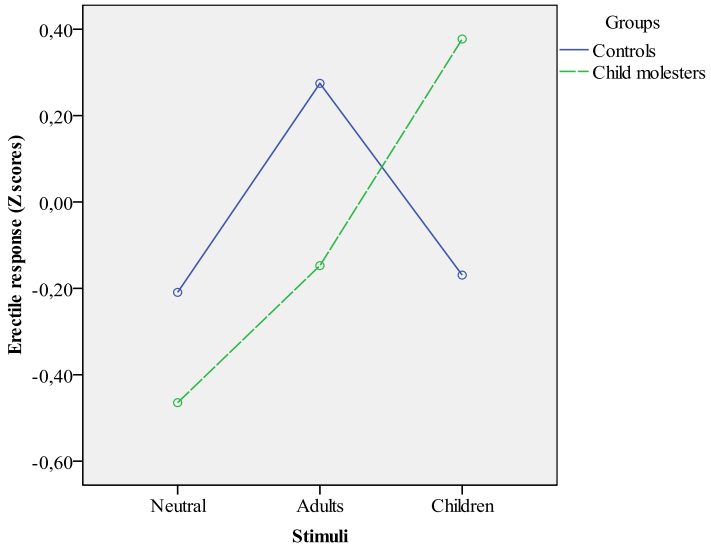

Figure 4. Erectile response in Z scores for non-deviant control subjects (n=23) and child molesters (n=11) on the different stimuli categories, i.e. Neutral, Adults and Children.

The repeated measures ANOVA performed on GRAD gives a significant principal effect for Stimuli (Λ=0.583; F(2,32)=11.467 ; p <.001) and Groups (F(1,33)=4.576; p <.05), but not for the interaction between both factors (Λ=0.985; F(2,32)=0.245 ; p =N.S.). Essentially, pairwise comparisons for the Stimuli factor indicate that each stimulus requires scanning behaviours according to its geometry with larger adult stimuli entailing a more sweeping GRAD behaviour around the VMP compared to smaller child stimuli (see table 1 and figure 5). The neutral stimulus, however, sets itself apart with respect to GRAD, and does this without distinguishing itself from the Child stimuli, which is probably attributable to the fact that a less interesting sexually neutral stimulus does not induce a comparable visual exploration in terms of the breadth and dynamics of the scanning movement. Average GRAD results with this last stimulus seem to range somewhere between those obtained with the Adult and the Child sexual stimuli. GRAD results express differences in kinematics which appear stimulus driven, i.e. which are related to the exercise of extracting perceptual information from the scene. As for the group difference, GRAD is lower for child molester participants than for non-deviants which means that the gaze of the child molesters dwelled in average more steadily in the VMP's vicinity (i.e. the sexual features of the characters; see figure 5). These results give support to the concept according to which sexual preoccupation and disinhibition are higher amongst sexual offenders than amongst non deviant community subjects (Kafka, 2003; Marshall & Marshall, 2006).

Table 1. Pairwise comparison based on LSD for GRAD and category of stimuli

(I)Stimuli	(J) Stimuli	Mean difference (I-J)	Std Error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
Neutral	Adults	-1,185*	,577	,048	-2,359	-,010
	Children	1,622	1,026	,124	-,467	3,710
Adults	Neutral	1,185*	,577	,048	,010	2,359
	Children	2,806*	,730	,001	1,321	4,292
Children	Neutral	-1,622	1,026	,124	-3,710	,467
	Adults	-2,806*	,730	,001	-4,292	-1,321

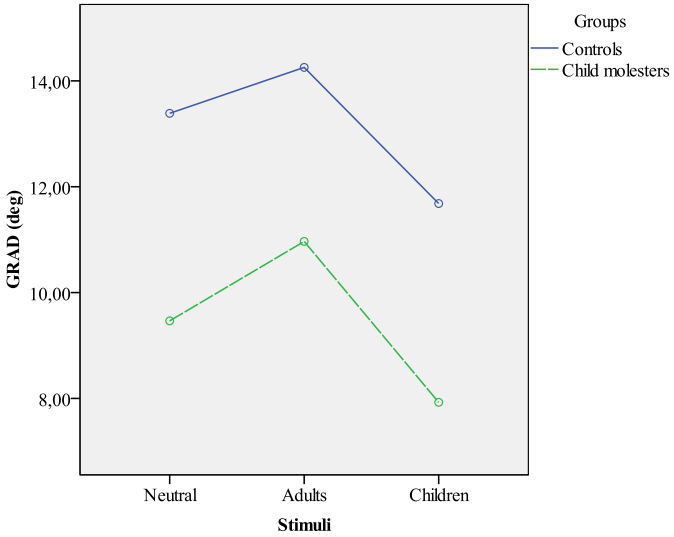

Figure 5. Gaze behaviour as expressed in radial angular deviation (GRAD) for non-deviant control subjects (n=24) and child molesters (n=11) on the different stimuli categories, i.e. Neutral, Adults and Children.

As for GRAD, GRADV turns out to be significantly different across groups ($F(1,36)=7.522$; $p < .01$) and stimulus conditions ($\Lambda=0.757$; $F(2,35)=5.609$; $p < .01$), but without a significant interaction effect between both factors ($\Lambda=0.975$; $F(2,35)=0.443$; p=N.S.). Pairwise comparisons allows the understanding that smaller child characters lead to a lesser velocity in their scrutinizing compared to the larger adult and neutral ones, the latter entailing comparable GRAD velocities on that matter (see Table 2 and figure 6). Otherwise, child molester participants are slower than non-deviant subjects in their visual scanning of the stimuli considered indiscriminately. This may be attributable to intrinsic neurobiological differences between non-deviants and sexually deviant subjects concerning the manner in which they perceptually extract sexual information. This may also result from the fact that child molesters were more medicated than non-deviant subjects. These questions will be further considered in the Discussion.

Table 2. Pairwise comparison based on LSD for GRADV and category of stimuli

(I) Stimuli	(J) Stimuli	Mean difference (I-J)	Std Error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
Neutral	Adults	,011	,016	,492	-,022	,045
	Children	,054*	,022	,017	,010	,097
Adults	Neutral	-,011	,016	,492	-,045	,022
	Children	,042*	,013	,002	,017	,068
Children	Neutral	-,054*	,022	,017	-,097	-,010
	Adults	-,042*	,013	,002	-,068	-,017

Note. $N = 38$. GRADV = gaze radial angular coefficient of variation. $*p < .05$, two tailed.

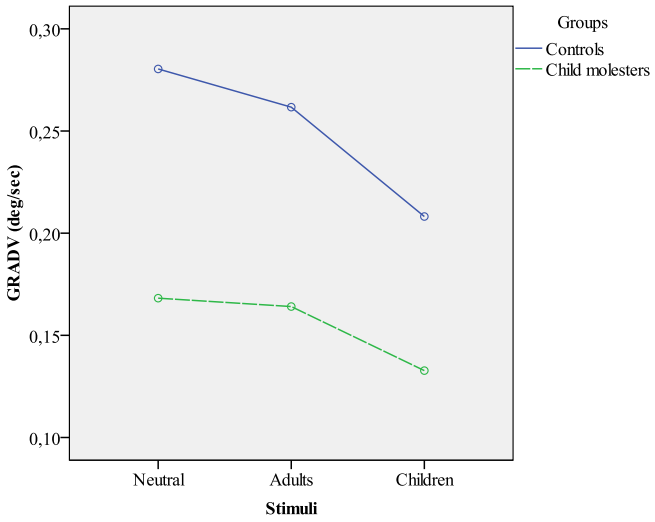

Figure 6. The velocity of gaze radial angular deviation (GRADV) as expressed in degree per second, for non-deviant control subjects (n=27) and child molesters (n=11) on the different stimuli categories, i.e. Neutral, Adults and Children.

The repeated measures ANOVA performed on GRADCV reveals similar results to those found with GRAD and GRADV, i.e. a significant principal effect for Stimuli (Λ=0.753; F(2,34)=5.589 ; p <.01) and Groups (F(1,35)=7.882; p <.01), but not for the interaction between both factors (Λ=0.951; F(2,34)=0.873 ; p =N.S.). Here again pairwise comparisons show that the variability of the scanning behaviour around the VMP is stimulus driven, i.e. dictated by the geometry of the visual stimuli; the smaller Child stimuli bring a significantly lesser dispersion of visual exploration around the VMP compared to the Neutral and Adult ones (see table 3, figure 1 and 7). Furthermore, patterns of gaze dispersion displayed by the child molesters appear to be less focused and controlled in comparison to the ones presented by the control group. While this last result cannot be said to be specific to the preferred sexual stimuli of child molesters (i.e. the Child stimuli), a significant positive Pearson bivariate correlation between PPG and GRADCV responses to Child stimuli seem to point in that direction ($r^2 = .403, p < .05$) . In our sample, larger gaze variability when scrutinizing child stimuli comes with higher sexual arousal toward these same stimuli. With a size effect of 0.22 (partial Eta squared of 0.049) we would have to double our clinical sample size in order to reach a power of 80% to yield a statistically significant Groups X Stimuli difference on GRADCV.

Table3. Pairwise comparison based on LSD for GRADCV and category of stimuli

(I) Stimuli	(J) Stimuli	Mean difference (I-J)	Std Error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
Neutral	Adults	,032	,029	,280	-,027	,090
	Children	,098*	,032	,004	,034	,163
Adults	Neutral	-,032	,029	,280	-,090	,027
	Children	,067*	,025	,010	,017	,117
Children	Neutral	-,098*	,032	,004	-,163	-,034
	Adults	-,067*	,025	,010	-,117	-,017

Note. *N* = 37. GRADCV = gaze radial angular deviation velocity. *p < .05, two tailed.

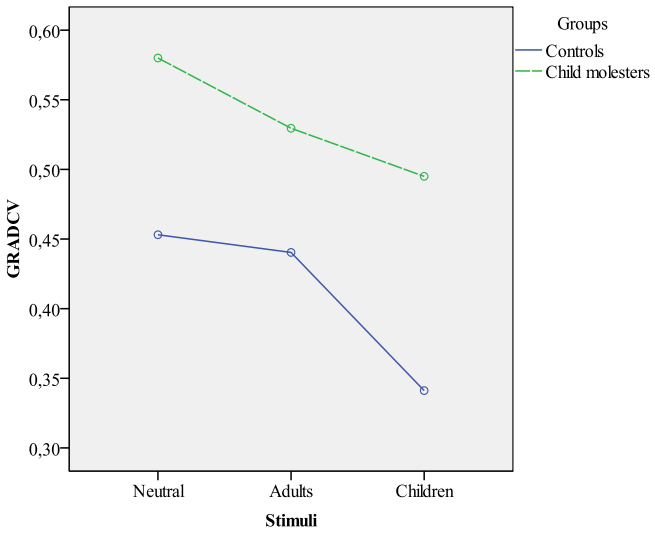

Figure 7.The gaze radial angular deviation coefficient of variation (GRADCV), for non-deviant control subjects (n=26) and child molesters (n=11) on the different stimuli categories, i.e. Neutral, Adults and Children.

7. DISCUSSION

The results obtained using simulations of social encounters with virtual naked characters give an idea of what immersive technologies can allow in sexual aggression research. By simulating realistic conditions similar to those leading to deviant sexual behaviours, it is believed that these kind of technologies can open the door to major steps forward in our understanding of sexual offenders and their clinical management (Laws and Gress, 2004; Renaud, Goyette et al., 2010; Renaud, Rouleau et al., 2002). When combined with PPG and other psychophysiological measurements, immersive virtual reality can be used as a powerful tool to probe into sex offenders' phenomenology, that is into their subjective experience of situations directly or indirectly associated with their sexual disorder. Such an advantage in ecological validity can be achieved through the embedding of the human subject in the simulated situations, i.e. into a set of synthetic stimuli forming a critical context. In turn, this level of embeddedness generates the feeling of being present[1] and involved in a realistic situation with human interaction, thereby facilitating the enactment and emergence of the cognitions usually arising in real social interactions.

We must first remember that the child molesters in our study presented more pronounced erectile responses to the Child stimuli, which are evidently linked to their sexual disorder, but also in a more general way to the preparation of the sexual act with a prepubescent child. These results are in accordance with what we know of sexual preferences among child molesters and seem to support the use of animated synthetic characters to assess sexual preferences with that clinical population. This typical sexual arousal reaction presumably embodies a sexual cognition constrained or favoured by the sexual context in which it is embedded. It is, in the ecological psychology perspective, the carrying out of a sexual affordance based on the dispositions of the agent in this regard (Gibson, 1979; Renaud, Goyette et al., 2010). Being present with the proximal displaying of prepubescent features produces in paedophiles and child molesters a state of psychophysiological preparation for sexual aggression, the distal origins of which can be found in neurobiological and personal history factors, as advocated by the ITSO (Ward & Beech, 2006; Ward & Casey, 2010). These prepubescent visual features simulated in virtual immersion were in fact in resonance with child molesters' latent intentional dynamics oriented toward molesting children. In this sense, these participants, unlike the controls, can sometimes have as active agents the behavioural objective of sexually molesting prepubescent victims. This self-regulated intentionality that translates at some point into sexual arousal is actualized by the perceptual-motor exercise of extracting critical visual information (Renaud, Goyette et al., 2010).

Subjects from both groups presented distinct GRAD patterns while immersed with the virtual characters. This second set of results points toward a distinct intentional signature for child molesters in how they took into account the visual information which guided their sexual response. The gaze measurement technique

[1] Presence is a technical term in virtual reality research that refers to the psychological state or subjective perception that causes an individual to give in to illusions created by a computerized system (International society for presence research [ISPR], http://www.temple.edu/ispr/).

used yielded information on how the optic flow lived from the first person stance, was actively exploited to coordinate perception and action with sexual arousal (see figure 2). The temporal unfolding of this perceptual-motor coordination is in itself the signature of a self-regulated intentional dynamics (Renaud et al, 2009; Renaud, Goyette et al., 2010). Child molesters displayed a slower, less stable and more sexually oriented gaze behaviour compared to controls'. These observations are in accordance with what is known of the neuropsychological deficits and sexual preoccupations of paedophiles and child molesters (Kafka, 2003; Marshall & Marshall, 2006; Suchy et al., 2009a, 2009b). This seems to be especially true for processing speed, visual-spatial coordination and sexual preoccupation. In this sense, our results are backing the Quinsey and Lalumière (1995) body shape detectors/appreciators failure hypothesis and relate the latter to sexual arousal response. As active agents in a virtual simulation of the encounter of a potential victim, child molesters in our study were placed in an acute state with their self-regulated processes either overwhelmed or catalyzed closer toward expressing sexually deviant behaviours (Hanson & Morton-Bourgon, 2005, 2009; Ward & Hudson, 1998).

As explained from the outset, self-regulation of offending is fundamentally based on a combination of internal and external processes which drive a person to manifest goal-oriented behaviours (Ward & Beech, 2006; Ward & Hudson, 1998). Furthermore, this behavioural regulation process, which is most probably nonlinear in nature, takes effect through the modulation of attention and perceptual-motor processes (Baumeister & Heatherton, 1996; Renaud, Goyette et al., 2010; Karoly, 1993; Ward & Hudson, 1998). This concept of self-regulation, when applied to sexual offense, provides an explanation for the interplay between deviant sexual preferences and sexual affordances as environmental opportunities to channel such sexual drive.

7.1. Limitations

Our study has methodological limitations and presents results that still need to be strengthened. Indeed, increasing the size of our sample is critical for us to be able to come to firmer conclusions. In order to tighten and better target our results, we will also have to control for the sexual orientation of our subjects (heterosexual, homosexual, bisexual) as well as for the exclusiveness and non exclusiveness of their paedophiliac orientation. In spite of these limitations, we believe that the results presented above are still quite promising on methodological and theoretical grounds.

8. CONCLUSION

To conclude, results and theoretical argumentations presented above allow to foresee in which ways concepts coming from Gibsonian ecological psychology combined with a virtual reality-based methodology might improve our understanding of deviant human sexuality, particularly paedophilia and child molestation. It appears to be a promising way to probe into how distal and proximal factors interact dynamically to shape sexual experiences as lived from the first-person stance. Ecological psychology is especially well suited in this sense to flesh out the concept of self-regulation of offending by putting into environmental context core neuropsychological processes proposed in the ITSO. It gives meaning to how prepubescent features are actively extracted by CM's perceptual-motor processes and how these features are indeed lived as sexual affordances and sexual presence by these individuals.

Virtual reality and related simulation technologies might indeed change the way we do research and clinical practice with sex offenders. Assessment of sexual preferences, as proposed in this article, but also other dimensions of sexual aggression can be addressed through virtual reality. For instance, the coupling of this kind of methodology to neurofeedback and real-time brain-computer interface might well give rise to new therapeutics for deviant sexual behaviour in the emerging field of neurorehabilitation (Birbaumer & Cohen, 2007; Renaud et al., 2011; Sitaram, Caria & Birbaumer, 2009).

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